8.0 Introduction to Memory
class="introduction"

Photographs can trigger our memories and bring past experiences back to life. (credit: modification of work by Cory Zanker)

We may be top-notch learners, but if we don’t have a way to store what we’ve learned, what good is the knowledge we’ve gained?

We have an amazing capacity for memory, but how, exactly, do we process and store information? Are there different kinds of memory, and if so, what

characterizes the different types? How, exactly, do we retrieve our memories? And why do we forget? This chapter will explore these questions as we learn about memory.

References

Abel, M., & Bäuml, K.-H. T. (2013). Sleep can reduce proactive interference. *Memory, 22*(4), 332–339. doi:10.1080/09658211.2013.785570. Retrieved from http://www.psychologie.uni-regensburg.de/Baeuml/papers_in_press/sleepPI.pdf

Anderson, N. S. (1969). The influence of acoustic similarity on serial recall of letter sequences. *Quarterly Journal of Experimental Psychology, 21*(3), 248–255.

Anderson, R. C. (1984). Role of the reader's schema in comprehension, learning, and memory. In R. C. Anderson, J. Osborn, & R. J. Tierney (Eds.), *Learning to read in American schools: Basal Readers and Content Texts* (pp. 243–257). Hillsdale, NJ: Erlbaum.

Atkinson, R. C., & Shiffrin, R. M. (1968). Human memory: A proposed system and its control processes. In K. W. Spence & J. T. Spence (Eds.), *The psychology of learning and motivation: Volume 2* (pp. 89–195). New York, NY: Academic Press.

Baddeley, A. (2004). *Your memory: A user's guide*. Richmond Hill, Canada: Firefly Books.

Baddeley, A. D., & Hitch, G. (1974). Working memory. In G. H. Bower (Ed.), *The psychology of learning and motivation: Advances in research and theory* (Vol. 8, pp. 47–89). New York, NY: Academic Press.

Bayley, P. J., & Squire, L. R. (2002). Medial temporal lobe amnesia: Gradual acquisition of factual information by nondeclarative memory. *Journal of Neuroscience, 22*, 5741–5748.

Bellezza, F. S. (1981). Mnemonic devices: Classification, characteristics and criteria. *Review of Educational Research, 51*, 247–275.

Benjamin N. Cardozo School of Law, Yeshiva University. (2009). Reevaluating lineups: Why witnesses make mistakes and how to reduce the chance of a misidentification. Retrieved from The Innocence Project website: http://www.innocenceproject.org/docs/Eyewitness_ID_Report.pdf

Blockland, A. (1996). Acetylcholine: A neurotransmitter for learning and memory? *Brain Research Reviews, 21*, 285–300.

Bodie, G. D., Powers, W. G., & Fitch-Hauser, M. (2006). Chunking, priming, and active learning: Toward an innovative approach to teaching communication-related skills. *Interactive Learning Environment, 14*(2), 119–135.

Bousfield, W. (1935). The occurrence of clustering in the recall of randomly arranged associates. *Journal of General Psychology, 49*, 229–240.

Bransford, J. D., & McCarrell, N. S. (1974). A sketch of a cognitive approach to comprehension. In W. B. Weimer & D. J. Palermo (Eds.), *Cognition and the symbolic processes* (pp. 189–229). Hillsdale, NJ: Lawrence Erlbaum Associates.

Briere, J., & Conte, J. (1993). Self-reported amnesia for abuse in adults molested as children. *Journal of Traumatic Stress, 6*, 21–31.

Carli, L. (1999). Cognitive reconstruction, hindsight, and reactions to victims and perpetrators. *Personality and Social Psychology Bulletin, 25*(8), 966–979. doi:10.1177/01461672992511005

Ceci, S. J., & Bruck, M. (1993). Child witness: Translating research into policy. *Social Policy Report, 7*(3), 1–30.

Ceci, S. J., & Bruck, M. (1995). *Jeopardy in the courtroom: A scientific analysis of children's testimony.* Washington, DC: American Psychological Association.

Cheit, R. E. (2007). *The recovered memory project.* Retrieved from http://blogs.brown.edu/recoveredmemory/.

Christianson, S. A. (1992). *The handbook of emotion and memory: Research and theory*. Hillsdale, NJ: Erlbaum.

Clark, R. E., Zola, S. M., & Squire, L. R. (2000). Impaired recognition memory in rats after damage to the hippocampus. *The Journal of Neuroscience, 20*(23), 8853–8860.

Corkin, S. (1965). Tactually-guided maze learning in man: Effects of unilateral cortical excisions and bilateral hippocampal lesions. *Neuropsychologia, 3*, 339–351.

Corkin, S. (1968). Acquisition of motor skill after bilateral medial temporal-lobe excision. *Neuropsychologia, 6*, 255–264.

Corkin, S., Amaral D. G., González, R. G., Johnson, K. A., & Hyman, B. T. (1997). H. M.'s medial temporal lobe lesion: Findings from magnetic resonance imaging. *Journal of Neuroscience, 17*(10), 3964–3979.

Craik, F. I. M., & Lockhart, R. S. (1972). Levels of processing: A framework for memory research. *Journal of Verbal Learning and Verbal Behavior, 11*, 671–684.

Craik, F. I. M., Moroz, T. M., Moscovitch, M., Stuss, D. T., Winocur, G., Tulving, E., & Kapur, S. (1999). In search of the self: A positron emission tomography study. *Psychological Science, 10*(1), 26–34.

Craik, F. I. M., & Tulving, E. (1975). Depth of processing and the retention of words in episodic memory. *Journal of Experimental Psychology, 104*(3), 268–294.

Craik, F. I. M., & Watkins, M. J. (1973). The role of rehearsal in short-term memory. *Journal of Verbal Learning and Verbal Behavior, 12*, 599–607.

Green, J. T., & Woodruff-Pak, D. S. (2000). Eyeblink classical conditioning in aging animals. In D. S. Woodruff-Pak & J. E. Steinmetz (Eds.), *Eyeblink classical conditioning: Animal models* (Vol. 2, pp.155–178). Boston, MA: Kluwer Academic.

Greenberg, D. L. (2004). President Bush's false [flashbulb] memory of 9/11/01. *Applied. Cognitive Psychology, 18*(3), 363–370. doi:10.1002/acp.1016

Devilly, G. J. (2007). If nothing happened why do I still hurt? An update on the memory wars. *InPsych, 29*(2), 16–18.

Ebbinghaus, H. (1964). *Memory: A contribution to experimental psychology* (H. A. Ruger & C. E. Bussenius, Trans.). New York, NY: Dover. (Original work published 1885)

Goodman, G. S. (2006). Children's eyewitness memory: A modern history and contemporary commentary. *Journal of Social Issues, 62*, 811–832.

Hassabis D., & Maguire E. A. (2007). Deconstructing episodic memory with construction. *Trends in Cognitive Sciences*, *11*(7), 299–306.

Jacobs, J. (1887). Experiments on "prehension." *Mind, 12*, 75–79.

Josselyn, J. A. (2010). Continuing the search for the engram: Examining the mechanism of fear memories. *Journal of Psychiatry Neuroscience, 35*(4), 221–228.

Kapur, S., Craik, F. I. M., Tulving, E., Wilson, A. A., Houle, S., & Brown, G. M. (1994). Neuroanatomical correlates of encoding in episodic memory: Levels of processing effect. *Proceedings of the National Academy of Sciences of the United States of America*, *91*(6), 208–2011.

Lashley K. S. (1950). In search of the engram. *Society of Experimental Biology Symposium, 4: Psychological Mechanisms in Animal Behavior*. Cambridge, UK: Cambridge University Press.

Loftus, E. F., & Palmer, J. C. (1974). Reconstruction of auto-mobile destruction: An example of the interaction between language and memory. *Journal of Verbal Learning and Verbal Behavior, 13*, 585–589.

MacLeod, C. M., Gopie, N., Hourihan, K. L., Neary, K. R., & Ozubko, J. D. (2010). The production effect: Delineation of a phenomenon. *Journal of*

Experimental Psychology: Learning, Memory, and Cognition, *36*(3), 671–685.

Mayford, M., Siegelbaum, S. A., & Kandel, E. R. (2012). *Synapses and memory storage.* New York, NY: Cold Spring Harbor Perspectives in Biology, Cold Spring Harbor Laboratory Press.

McGaugh, J. L. (2003). *Memory and emotion: The making of lasting memories*. New York, NY: Columbia University Press.

McLeod, S. A. (2011). Anterograde amnesia [Web log post]. Retrieved from http://www.simplypsychology.org/anterograde-amnesia.html

Miller, G. A. (1956). The magical number seven, plus or minus two: Some limits on our capacity for processing information. *Psychological Review, 68*, 81–87.

Myhrer, T. (2003). Neurotransmitter systems involved in learning and memory in the rat: A meta-analysis based on studies of four behavioral tasks. *Brain Research Reviews, 41*(2–3), 268–287.

Newseum. (n.d.). G-men and journalists: D. C. sniper [Web log post]. Retrieved from http://www.newseum.org/exhibits-and-theaters/temporary-exhibits/g-men-and-journalists/sniper/

Nickerson, R. S., & Adams, M. J. (1979). Long-term memory for a common object. *Cognitive Psychology, 11*(3), 287–307.

Paivio, A. (1986). *Mental representations: A dual coding approach*. New York, NY: Oxford University Press.

Parker, E. S., Cahill, L., & McGaugh, J. L. (2006). A case of unusual autobiographical remembering. *Neurocase, 12*, 35–49.

Payne, B. K., Jacoby, L. L., & Lambert, A. J. (2004). Memory monitoring and the control of stereotype distortion. *Journal of Experimental Social Psychology, 40*, 52–64.

Pew Research Center (2011, September 1). *Ten years after 9/11: United in remembrance, divided over policies.* Washington, DC: People Press.

Pipe, M.-E. (1996). Children's eyewitness memory. *New Zealand Journal of Psychology, 25*(2), 36–43.

Pipe, M.-E., Lamb, M., Orbach, Y., & Esplin, P. W. (2004). Recent research on children's testimony about experienced and witnessed events. *Developmental Review, 24*, 440–468.

Roediger, H. L., & DeSoto, K. A. (in press). The psychology of reconstructive memory. In J. Wright (Ed.), *International Encyclopedia of the Social and Behavioral sciences,* 2e. Oxford, UK: Elsevier.

Roediger, H. L., III, & McDermott, K. B. (2000). Tricks of memory. *Current Directions in Psychological Science, 9,* 123–127.

Rogers, T. B., Kuiper, N. A., & Kirker, W. S. (1977). Self-reference and the encoding of personal information. *Journal of Personal Social Psychology, 35*(9), 677–688.

Schacter, D. (2001). *The seven sins of memory: How the mind forgets and remembers.* New York, NY: Houghton Mifflin.

Steinmetz, J. E. (1999). A renewed interest in human classical eyeblink conditioning. *Psychological Science, 10,* 24–25.

Tigner, R. B. (1999). Putting memory research to good use. *College Teaching*, *47*(4), 149–152.

Tulving, E. (1972). Episodic and semantic memory. In E. Tulving & W. Dolandson (Eds.), *Organization of memory* (pp. 381–403). New York, NY: Academic Press.

Tulving, E. (2002, February). Episodic memory: From mind to brain. *Annual Review of Psychology, 53*, 1–25. doi:10.1146/annurev.psych.53.100901.135114

van Praag, H. (2008). Neurogenesis and exercise: Past and future directions. *NeuroMolecular Medicine, 10*(2), 128–140.

Wells, G. L., & Quinlivan, D. S. (2009). Suggestive eyewitness identification procedures and the Supreme Court's reliability test in light of eyewitness science: 30 years later. *Law and Human Behavior, 33*, 1–24. doi:10.1007/s10979-008-9130-3

Wrubel, B. (Writer), & Spiller, M. (Director). (2010). The Old Wagon [Television series episode]. In S. Levitan & C. Lloyd (Executive producers), *Modern Family*. 20th Century Fox Television.

Yogo, M., & Fujihara, S. (2008). Working memory capacity can be improved by expressive writing: A randomized experiment in a Japanese sample. *British Journal of Health Psychology, 13*(1), 77–80. doi:10.1348/135910707X252440

8.1 How Memory Functions
By the end of this section, you will be able to:

- Discuss the three basic functions of memory
- Describe the three stages of memory storage
- Describe and distinguish between procedural and declarative memory and semantic and episodic memory

Memory is an information processing system; therefore, we often compare it to a computer. **Memory** is the set of processes used to encode, store, and retrieve information over different periods of time ([link]).

ENCODING

We get information into our brains through a process called **encoding**, which is the input of information into the memory system. Once we receive sensory information from the environment, our brains label or code it. We organize the information with other similar information and connect new concepts to existing concepts. Encoding information occurs through automatic processing and effortful processing.

If someone asks you what you ate for lunch today, more than likely you could recall this information quite easily. This is known as **automatic processing**, or the encoding of details like time, space, frequency, and the meaning of words. Automatic processing is usually done without any conscious awareness. Recalling the last time you studied for a test is another example of automatic processing. But what about the actual test material you studied? It probably required a lot of work and attention on your part in order to encode that information. This is known as **effortful processing** ([link]).

There are three types of encoding. The encoding of words and their meaning is known as **semantic encoding**. It was first demonstrated by William Bousfield (1935) in an experiment in which he asked people to memorize words. The 60 words were actually divided into 4 categories of meaning, although the participants did not know this because the words were randomly presented. When they were asked to remember the words,

they tended to recall them in categories, showing that they paid attention to the meanings of the words as they learned them.

Visual encoding is the encoding of images, and **acoustic encoding** is the encoding of sounds, words in particular. To see how visual encoding works, read over this list of words: *car, level, dog, truth, book, value*. If you were asked later to recall the words from this list, which ones do you think you'd most likely remember? You would probably have an easier time recalling the words *car, dog,* and *book*, and a more difficult time recalling the words *level, truth,* and *value*. Why is this? Because you can recall images (mental pictures) more easily than words alone. When you read the words *car, dog,* and *book* you created images of these things in your mind. These are concrete, high-imagery words. On the other hand, abstract words like *level, truth,* and *value* are low-imagery words. High-imagery words are encoded both visually and semantically (Paivio, 1986), thus building a stronger memory.

Now let's turn our attention to acoustic encoding. You are driving in your car and a song comes on the radio that you haven't heard in at least 10 years, but you sing along, recalling every word. In the United States, children often learn the alphabet through song, and they learn the number of days in each month through rhyme: "Thirty days hath September, / April, June, and November; / All the rest have thirty-one, / Save February, with twenty-eight days clear, / And twenty-nine each leap year." These lessons are easy to remember because of acoustic encoding. We encode the sounds the words make. This is one of the reasons why much of what we teach young children is done through song, rhyme, and rhythm.

Which of the three types of encoding do you think would give you the best memory of verbal information? Some years ago, psychologists Fergus Craik and Endel Tulving (1975) conducted a series of experiments to find out. Participants were given words along with questions about them. The questions required the participants to process the words at one of the three levels. The visual processing questions included such things as asking the participants about the font of the letters. The acoustic processing questions asked the participants about the sound or rhyming of the words, and the semantic processing questions asked the participants about the meaning of

the words. After participants were presented with the words and questions, they were given an unexpected recall or recognition task.

Words that had been encoded semantically were better remembered than those encoded visually or acoustically. Semantic encoding involves a deeper level of processing than the shallower visual or acoustic encoding. Craik and Tulving concluded that we process verbal information best through semantic encoding, especially if we apply what is called the self-reference effect. The **self-reference effect** is the tendency for an individual to have better memory for information that relates to oneself in comparison to material that has less personal relevance (Rogers, Kuiper & Kirker, 1977). Could semantic encoding be beneficial to you as you attempt to memorize the concepts in this chapter?

STORAGE

Once the information has been encoded, we have to somehow have to retain it. Our brains take the encoded information and place it in storage. **Storage** is the creation of a permanent record of information.

In order for a memory to go into storage (i.e., long-term memory), it has to pass through three distinct stages: Sensory Memory, Short-Term Memory, and finally Long-Term Memory. These stages were first proposed by Richard Atkinson and Richard Shiffrin (1968). Their model of human memory,called Atkinson-Shiffrin (A-S), is based on the belief that we process memories in the same way that a computer processes information.

But A-S is just one model of memory. Others, such as Baddeley and Hitch (1974), have proposed a model where short-term memory itself has different forms. In this model, storing memories in short-term memory is like opening different files on a computer and adding information. The type of short-term memory (or computer file) depends on the type of information received. There are memories in visual-spatial form, as well as memories of spoken or written material, and they are stored in three short-term systems: a visuospatial sketchpad, an episodic buffer, and a phonological loop. According to Baddeley and Hitch, a central executive part of memory

supervises or controls the flow of information to and from the three short-term systems.

Sensory Memory

In the Atkinson-Shiffrin model, stimuli from the environment are processed first in **sensory memory**: storage of brief sensory events, such as sights, sounds, and tastes. It is very brief storage—up to a couple of seconds. We are constantly bombarded with sensory information. We cannot absorb all of it, or even most of it. And most of it has no impact on our lives. For example, what was your professor wearing the last class period? As long as the professor was dressed appropriately, it does not really matter what she was wearing. Sensory information about sights, sounds, smells, and even textures, which we do not view as valuable information, we discard. If we view something as valuable, the information will move into our short-term memory system.

Short-Term Memory

Short-term memory (STM), also called working memory, is a temporary storage system that processes incoming sensory memory; sometimes it is called working memory. Short-term memory takes information from sensory memory and sometimes connects that memory to something already in long-term memory. Short-term memory storage lasts about 20 seconds. George Miller (1956), in his research on the capacity of memory, found that most people can retain about 7 items in STM. Some remember 5, some 9, so he called the capacity of STM 7 plus or minus 2.

Think of short-term memory as the information you have displayed on your computer screen—a document, a spreadsheet, or a web page. Then, information in short-term memory goes to long-term memory (you save it to your hard drive), or it is discarded (you delete a document or close a web browser). This step of **rehearsal**, the conscious repetition of information to

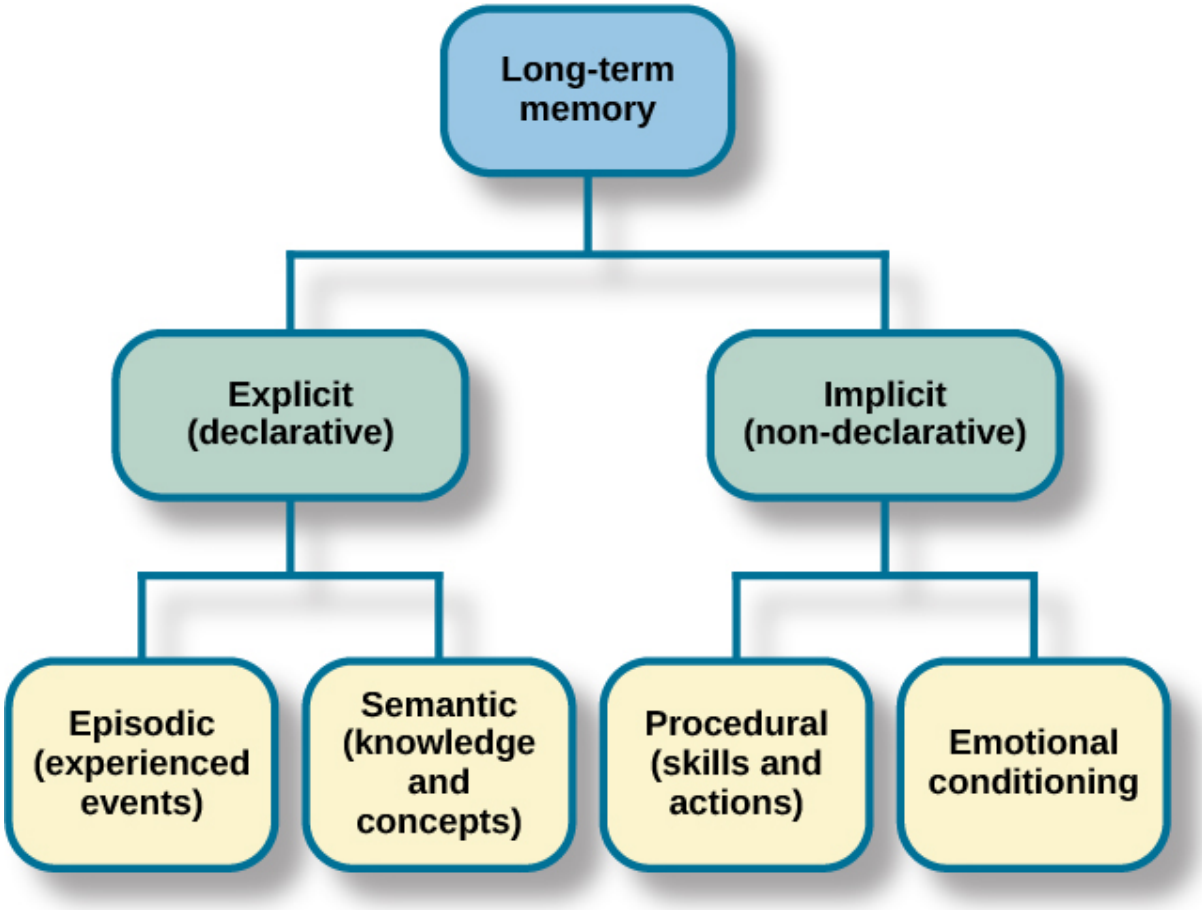
be remembered, to move STM into long-term memory is called **memory consolidation**.

Long-term Memory

Long-term memory (LTM) is the continuous storage of information. Unlike short-term memory, the storage capacity of LTM has no limits. It encompasses all the things you can remember that happened more than just a few minutes ago to all of the things that you can remember that happened days, weeks, and years ago. In keeping with the computer analogy, the information in your LTM would be like the information you have saved on the hard drive. It isn't there on your desktop (your short-term memory), but you can pull up this information when you want it, at least most of the time. Not all long-term memories are strong memories. Some memories can only be recalled through prompts. For example, you might easily recall a fact—"What is the capital of the United States?"—or a procedure—"How do you ride a bike?"—but you might struggle to recall the name of the restaurant you had dinner when you were on vacation in France last summer. A prompt, such as that the restaurant was named after its owner, who spoke to you about your shared interest in soccer, may help you recall the name of the restaurant.

Long-term memory is divided into two types: explicit and implicit ([link]). Understanding the different types is important because a person's age or particular types of brain trauma or disorders can leave certain types of LTM intact while having disastrous consequences for other types. **Explicit memories** are those we consciously try to remember and recall. For example, if you are studying for your chemistry exam, the material you are learning will be part of your explicit memory. (Note: Sometimes, but not always, the terms explicit memory and declarative memory are used interchangeably.)

Implicit memories are memories that are not part of our consciousness. They are memories formed from behaviors. Implicit memory is also called non-declarative memory.



There are two components of long-term memory: explicit and implicit. Explicit memory includes episodic and semantic memory. Implicit memory includes procedural memory and things learned through conditioning.

Procedural memory is a type of implicit memory: it stores information about how to do things. It is the memory for skilled actions, such as how to brush your teeth, how to drive a car, how to swim the crawl (freestyle) stroke. If you are learning how to swim freestyle, you practice the stroke: how to move your arms, how to turn your head to alternate breathing from side to side, and how to kick your legs. You would practice this many times until you become good at it. Once you learn how to swim freestyle and your body knows how to move through the water, you will never forget how to swim freestyle, even if you do not swim for a couple of decades. Similarly,

if you present an accomplished guitarist with a guitar, even if he has not played in a long time, he will still be able to play quite well.

Declarative memory has to do with the storage of facts and events we personally experienced. Explicit (declarative) memory has two parts: semantic memory and episodic memory. Semantic means having to do with language and knowledge about language. An example would be the question "what does *argumentative* mean?" Stored in our **semantic memory** is knowledge about words, concepts, and language-based knowledge and facts. For example, answers to the following questions are stored in your semantic memory:

Episodic memory is information about events we have personally experienced. The concept of episodic memory was first proposed about 40 years ago (Tulving, 1972). Since then, Tulving and others have looked at scientific evidence and reformulated the theory. Currently, scientists believe that episodic memory is memory about happenings in particular places at particular times, the what, where, and when of an event (Tulving, 2002). It involves recollection of visual imagery as well as the feeling of familiarity (Hassabis & Maguire, 2007).

RETRIEVAL

So you have worked hard to encode (via effortful processing) and store some important information for your upcoming final exam. How do you get that information back out of storage when you need it? The act of getting information out of memory storage and back into conscious awareness is known as **retrieval**. This would be similar to finding and opening a paper you had previously saved on your computer's hard drive. Now it's back on your desktop, and you can work with it again. Our ability to retrieve information from long-term memory is vital to our everyday functioning. You must be able to retrieve information from memory in order to do everything from knowing how to brush your hair and teeth, to driving to work, to knowing how to perform your job once you get there.

There are three ways you can retrieve information out of your long-term memory storage system: recall, recognition, and relearning. **Recall** is what

we most often think about when we talk about memory retrieval: it means you can access information without cues. For example, you would use recall for an essay test. **Recognition** happens when you identify information that you have previously learned after encountering it again. It involves a process of comparison. When you take a multiple-choice test, you are relying on recognition to help you choose the correct answer. Here is another example. Let's say you graduated from high school 10 years ago, and you have returned to your hometown for your 10-year reunion. You may not be able to recall all of your classmates, but you recognize many of them based on their yearbook photos.

The third form of retrieval is **relearning**, and it's just what it sounds like. It involves learning information that you previously learned. Whitney took Spanish in high school, but after high school she did not have the opportunity to speak Spanish. Whitney is now 31, and her company has offered her an opportunity to work in their Mexico City office. In order to prepare herself, she enrolls in a Spanish course at the local community center. She's surprised at how quickly she's able to pick up the language after not speaking it for 13 years; this is an example of relearning.

Summary

Memory is a system or process that stores what we learn for future use.

Our memory has three basic functions: encoding, storing, and retrieving information. Encoding is the act of getting information into our memory system through automatic or effortful processing. Storage is retention of the information, and retrieval is the act of getting information out of storage and into conscious awareness through recall, recognition, and relearning. The idea that information is processed through three memory systems is called the Atkinson-Shiffrin (A-S) model of memory. First, environmental stimuli enter our sensory memory for a period of less than a second to a few seconds. Those stimuli that we notice and pay attention to then move into short-term memory (also called working memory). According to the A-S model, if we rehearse this information, then it moves into long-term memory for permanent storage. Other models like that of Baddeley and Hitch suggest there is more of a feedback loop between short-term memory

and long-term memory. Long-term memory has a practically limitless storage capacity and is divided into implicit and explicit memory. Finally, retrieval is the act of getting memories out of storage and back into conscious awareness. This is done through recall, recognition, and relearning.

Review Questions

Exercise:

Problem:_____ is another name for short-term memory.

A. sensory memory
B. episodic memory
C. short-term memory
D. implicit memory

Solution:

C

Exercise:

Problem: The storage capacity of long-term memory is _____.

A. one or two bits of information
B. seven bits, plus or minus two
C. limited
D. essentially limitless

Solution:

D

Exercise:

Problem: The three functions of memory are _____.

A. automatic processing, effortful processing, and storage
B. encoding, processing, and storage
C. automatic processing, effortful processing, and retrieval
D. encoding, storage, and retrieval

Solution:

D

Critical Thinking Questions

Exercise:

Problem: Compare and contrast implicit and explicit memory.

Solution:

Both are types of long-term memory. Explicit memories are memories we consciously try to remember and recall. Explicit memory is also called declarative memory and is subdivided into episodic memory (life events) and semantic memory (words, ideas, and concepts). Implicit memories are memories that are not part of our consciousness; they are memories formed from behaviors. Implicit memory is also called non-declarative memory and includes procedural memory as well as things learned through classical conditioning.

Exercise:

Problem:

According to the Atkinson-Shiffrin model, name and describe the three stages of memory.

Solution:

According to the Atkinson-Shiffrin model, memory is processed in three stages. The first is sensory memory; this is very brief: 1–2 seconds. Anything not attended to is ignored. The stimuli we pay attention to then move into our short-term memory. Short-term memory can hold approximately 7 bits of information for around 20 seconds. Information here is either forgotten, or it is encoded into long-term memory through the process of rehearsal. Long-term memory is the permanent storage of information—its capacity is basically unlimited.

Exercise:

Problem:

Compare and contrast the two ways in which we encode information.

Solution:

Information is encoded through automatic or effortful processing. Automatic processing refers to all information that enters long-term memory without conscious effort. This includes things such as time, space, and frequency—for example, your ability to remember what you ate for breakfast today or the fact that you remember that you ran into your best friend in the supermarket twice this week. Effortful processing refers to encoding information through conscious attention and effort. Material that you study for a test requires effortful processing.

Glossary

acoustic encoding
: input of sounds, words, and music

Atkinson-Shiffrin model (A-S)

memory model that states we process information through three systems: sensory memory, short-term memory, and long-term memory

automatic processing
: encoding of informational details like time, space, frequency, and the meaning of words

declarative memory
: type of long-term memory of facts and events we personally experience

effortful processing
: encoding of information that takes effort and attention

encoding
: input of information into the memory system

episodic memory
: type of declarative memory that contains information about events we have personally experienced, also known as autobiographical memory

explicit memory
: memories we consciously try to remember and recall

implicit memory
: memories that are not part of our consciousness

long-term memory (LTM)
: continuous storage of information

memory
: system or process that stores what we learn for future use

memory consolidation
: active rehearsal to move information from short-term memory into long-term memory

procedural memory

type of long-term memory for making skilled actions, such as how to brush your teeth, how to drive a car, and how to swim

recall
: accessing information without cues

recognition
: identifying previously learned information after encountering it again, usually in response to a cue

rehearsal
: conscious repetition of information to be remembered

relearning
: learning information that was previously learned

retrieval
: act of getting information out of long-term memory storage and back into conscious awareness

self-reference effect
: tendency for an individual to have better memory for information that relates to oneself in comparison to material that has less personal relevance

semantic encoding
: input of words and their meaning

semantic memory
: type of declarative memory about words, concepts, and language-based knowledge and facts

sensory memory
: storage of brief sensory events, such as sights, sounds, and tastes

short-term memory (STM)
: (also, working memory) holds about seven bits of information before it is forgotten or stored, as well as information that has been retrieved

and is being used

storage
: creation of a permanent record of information

visual encoding
: input of images

8.2 Parts of the Brain Involved with Memory

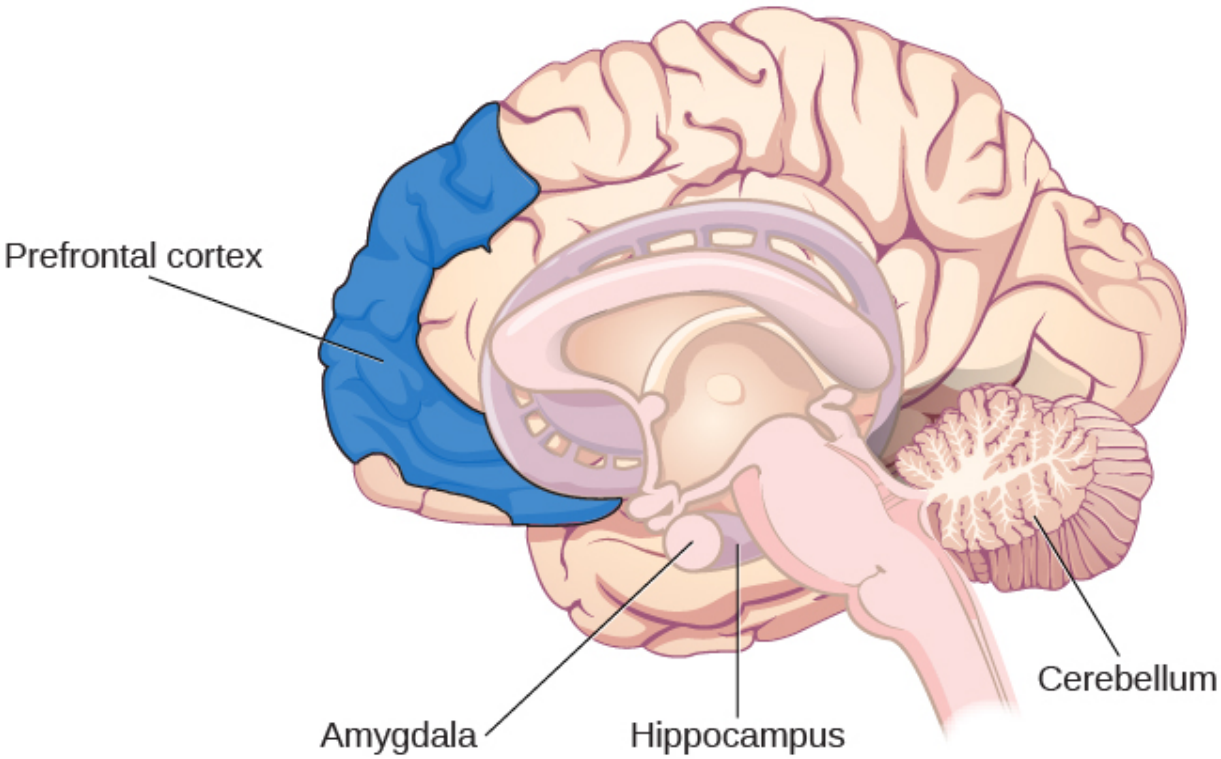
By the end of this section, you will be able to:

- Explain the brain functions involved in memory
- Recognize the roles of the hippocampus, amygdala, and cerebellum

Are memories stored in just one part of the brain, or are they stored in many different parts of the brain? Karl Lashley began exploring this problem, about 100 years ago, by making lesions in the brains of animals such as rats and monkeys. He was searching for evidence of the **engram**: the group of neurons that serve as the "physical representation of memory" (Josselyn, 2010). First, Lashley (1950) trained rats to find their way through a maze. Then, he used the tools available at the time—in this case a soldering iron —to create lesions in the rats' brains, specifically in the cerebral cortex. He did this because he was trying to erase the engram, or the original memory trace that the rats had of the maze.

Lashley did not find evidence of the engram, and the rats were still able to find their way through the maze, regardless of the size or location of the lesion. Based on his creation of lesions and the animals' reaction, he formulated the **equipotentiality hypothesis**: if part of one area of the brain involved in memory is damaged, another part of the same area can take over that memory function (Lashley, 1950). Although Lashley's early work did not confirm the existence of the engram, modern psychologists are making progress locating it. Eric Kandel, for example, spent decades working on the synapse, the basic structure of the brain, and its role in controlling the flow of information through neural circuits needed to store memories (Mayford, Siegelbaum, & Kandel, 2012).

Many scientists believe that the entire brain is involved with memory. However, since Lashley's research, other scientists have been able to look more closely at the brain and memory. They have argued that memory is located in specific parts of the brain, and specific neurons can be recognized for their involvement in forming memories. The main parts of the brain involved with memory are the amygdala, the hippocampus, the cerebellum, and the prefrontal cortex ([link]).



The amygdala is involved in fear and fear memories. The hippocampus is associated with declarative and episodic memory as well as recognition memory. The cerebellum plays a role in processing procedural memories, such as how to play the piano. The prefrontal cortex appears to be involved in remembering semantic tasks.

THE AMYGDALA

First, let's look at the role of the amygdala in memory formation. The main job of the amygdala is to regulate emotions, such as fear and aggression ([link]). The amygdala plays a part in how memories are stored because storage is influenced by stress hormones. For example, one researcher experimented with rats and the fear response (Josselyn, 2010). Using Pavlovian conditioning, a neutral tone was paired with a foot shock to the rats. This produced a fear memory in the rats. After being conditioned, each time they heard the tone, they would freeze (a defense response in rats), indicating a memory for the impending shock. Then the researchers induced

cell death in neurons in the lateral amygdala, which is the specific area of the brain responsible for fear memories. They found the fear memory faded (became extinct). Because of its role in processing emotional information, the amygdala is also involved in memory consolidation: the process of transferring new learning into long-term memory. The amygdala seems to facilitate encoding memories at a deeper level when the event is emotionally arousing.

THE HIPPOCAMPUS

Another group of researchers also experimented with rats to learn how the hippocampus functions in memory processing ([link]). They created lesions in the hippocampi of the rats, and found that the rats demonstrated memory impairment on various tasks, such as object recognition and maze running. They concluded that the hippocampus is involved in memory, specifically normal recognition memory as well as spatial memory (when the memory tasks are like recall tests) (Clark, Zola, & Squire, 2000). Another job of the hippocampus is to project information to cortical regions that give memories meaning and connect them with other connected memories. It also plays a part in memory consolidation: the process of transferring new learning into long-term memory.

Injury to this area leaves us unable to process new declarative memories. One famous patient, known for years only as H. M., had both his left and right temporal lobes (hippocampi) removed in an attempt to help control the seizures he had been suffering from for years (Corkin, Amaral, González, Johnson, & Hyman, 1997). As a result, his declarative memory was significantly affected, and he could not form new semantic knowledge. He lost the ability to form new memories, yet he could still remember information and events that had occurred prior to the surgery.

THE CEREBELLUM AND PREFRONTAL CORTEX

Although the hippocampus seems to be more of a processing area for explicit memories, you could still lose it and be able to create implicit memories (procedural memory, motor learning, and classical conditioning), thanks to your cerebellum ([link]). For example, one classical conditioning

experiment is to accustom subjects to blink when they are given a puff of air. When researchers damaged the cerebellums of rabbits, they discovered that the rabbits were not able to learn the conditioned eye-blink response (Steinmetz, 1999; Green & Woodruff-Pak, 2000).

Other researchers have used brain scans, including positron emission tomography (PET) scans, to learn how people process and retain information. From these studies, it seems the prefrontal cortex is involved. In one study, participants had to complete two different tasks: either looking for the letter *a* in words (considered a perceptual task) or categorizing a noun as either living or non-living (considered a semantic task) (Kapur et al., 1994). Participants were then asked which words they had previously seen. Recall was much better for the semantic task than for the perceptual task. According to PET scans, there was much more activation in the left inferior prefrontal cortex in the semantic task. In another study, encoding was associated with left frontal activity, while retrieval of information was associated with the right frontal region (Craik et al., 1999).

NEUROTRANSMITTERS

There also appear to be specific neurotransmitters involved with the process of memory, such as epinephrine, dopamine, serotonin, glutamate, and acetylcholine (Myhrer, 2003). There continues to be discussion and debate among researchers as to which neurotransmitter plays which specific role (Blockland, 1996). Although we don’t yet know which role each neurotransmitter plays in memory, we do know that communication among neurons via neurotransmitters is critical for developing new memories. Repeated activity by neurons leads to increased neurotransmitters in the synapses and more efficient and more synaptic connections. This is how memory consolidation occurs.

It is also believed that strong emotions trigger the formation of strong memories, and weaker emotional experiences form weaker memories; this is called **arousal theory** (Christianson, 1992). For example, strong emotional experiences can trigger the release of neurotransmitters, as well as hormones, which strengthen memory; therefore, our memory for an emotional event is usually better than our memory for a non-emotional

event. When humans and animals are stressed, the brain secretes more of the neurotransmitter glutamate, which helps them remember the stressful event (McGaugh, 2003). This is clearly evidenced by what is known as the flashbulb memory phenomenon.

Summary

Beginning with Karl Lashley, researchers and psychologists have been searching for the engram, which is the physical trace of memory. Lashley did not find the engram, but he did suggest that memories are distributed throughout the entire brain rather than stored in one specific area. Now we know that three brain areas do play significant roles in the processing and storage of different types of memories: cerebellum, hippocampus, and amygdala. The cerebellum's job is to process procedural memories; the hippocampus is where new memories are encoded; the amygdala helps determine what memories to store, and it plays a part in determining where the memories are stored based on whether we have a strong or weak emotional response to the event. Strong emotional experiences can trigger the release of neurotransmitters, as well as hormones, which strengthen memory, so that memory for an emotional event is usually stronger than memory for a non-emotional event. This is shown by what is known as the flashbulb memory phenomenon: our ability to remember significant life events. However, our memory for life events (autobiographical memory) is not always accurate.

Review Questions

Exercise:

Problem: This physical trace of memory is known as the _____.

A. engram
B. Lashley effect
C. Deese-Roediger-McDermott Paradigm
D. flashbulb memory effect

Solution:

A

Exercise:

Problem:

An exceptionally clear recollection of an important event is a (an) _____.

A. engram
B. arousal theory
C. flashbulb memory
D. equipotentiality hypothesis

Solution:

C

Critical Thinking Questions

Exercise:

Problem:

What might happen to your memory system if you sustained damage to your hippocampus?

Solution:

Because your hippocampus seems to be more of a processing area for your explicit memories, injury to this area could leave you unable to process new declarative (explicit) memories; however, even with this loss, you would be able to create implicit memories (procedural memory, motor learning and classical conditioning).

Glossary

arousal theory
: strong emotions trigger the formation of strong memories and weaker emotional experiences form weaker memories

engram
: physical trace of memory

equipotentiality hypothesis
: some parts of the brain can take over for damaged parts in forming and storing memories

flashbulb memory
: exceptionally clear recollection of an important event

8.3 Problems with Memory
By the end of this section, you will be able to:

- Compare and contrast the two types of amnesia
- Discuss the unreliability of eyewitness testimony
- Discuss encoding failure
- Discuss the various memory errors
- Compare and contrast the two types of interference

AMNESIA

Amnesia is the loss of long-term memory that occurs as the result of disease, physical trauma, or psychological trauma.

Anterograde Amnesia

There are two common types of amnesia: anterograde amnesia and retrograde amnesia ([link]). Anterograde amnesia is commonly caused by brain trauma, such as a blow to the head. With **anterograde amnesia**, you cannot remember new information, although you can remember information and events that happened prior to your injury. The hippocampus is usually affected (McLeod, 2011). This suggests that damage to the brain has resulted in the inability to transfer information from short-term to long-term memory; that is, the inability to consolidate memories.

Many people with this form of amnesia are unable to form new episodic or semantic memories, but are still able to form new procedural memories (Bayley & Squire, 2002). This was true of H. M., which was discussed earlier. The brain damage caused by his surgery resulted in anterograde amnesia. H. M. would read the same magazine over and over, having no memory of ever reading it—it was always new to him. He also could not remember people he had met after his surgery. If you were introduced to H. M. and then you left the room for a few minutes, he would not know you upon your return and would introduce himself to you again. However, when presented the same puzzle several days in a row, although he did not

remember having seen the puzzle before, his speed at solving it became faster each day (because of relearning) (Corkin, 1965, 1968).

This diagram illustrates the timeline of retrograde and anterograde amnesia. Memory problems that extend back in time before the injury and prevent retrieval of information previously stored in long-term memory are known as retrograde amnesia. Conversely, memory problems that extend forward in time from the point of injury and prevent the formation of new memories are called anterograde amnesia.

Retrograde Amnesia

Retrograde amnesia is loss of memory for events that occurred prior to the trauma. People with retrograde amnesia cannot remember some or even all of their past. They have difficulty remembering episodic memories. What if you woke up in the hospital one day and there were people surrounding your bed claiming to be your spouse, your children, and your parents? The trouble is you don't recognize any of them. You were in a car accident, suffered a head injury, and now have retrograde amnesia. You don't remember anything about your life prior to waking up in the hospital. This may sound like the stuff of Hollywood movies, and Hollywood has been fascinated with the amnesia plot for nearly a century, going all the way back to the film *Garden of Lies* from 1915 to more recent movies such as the Jason Bourne trilogy starring Matt Damon and *50 First Dates* with Drew Barrymore. However, for real-life sufferers of retrograde amnesia, like

former NFL football player Scott Bolzan, the story is not a Hollywood movie. Bolzan fell, hit his head, and deleted 46 years of his life in an instant. He is now living with one of the most extreme cases of retrograde amnesia on record.

MEMORY CONSTRUCTION AND RECONSTRUCTION

The formulation of new memories is sometimes called **construction**, and the process of bringing up old memories is called **reconstruction**. Yet as we retrieve our memories, we also tend to alter and modify them. A memory pulled from long-term storage into short-term memory is flexible. New events can be added and we can change what we think we remember about past events, resulting in inaccuracies and distortions. People may not intend to distort facts, but it can happen in the process of retrieving old memories and combining them with new memories (Roediger and DeSoto, in press).

Suggestibility

When someone witnesses a crime, that person's memory of the details of the crime is very important in catching the suspect. Because memory is so fragile, witnesses can be easily (and often accidentally) misled due to the problem of suggestibility. **Suggestibility** describes the effects of misinformation from external sources that leads to the creation of false memories. In the fall of 2002, a sniper in the DC area shot people at a gas station, leaving Home Depot, and walking down the street. These attacks went on in a variety of places for over three weeks and resulted in the deaths of ten people. During this time, as you can imagine, people were terrified to leave their homes, go shopping, or even walk through their neighborhoods. Police officers and the FBI worked frantically to solve the crimes, and a tip hotline was set up. Law enforcement received over 140,000 tips, which resulted in approximately 35,000 possible suspects (Newseum, n.d.).

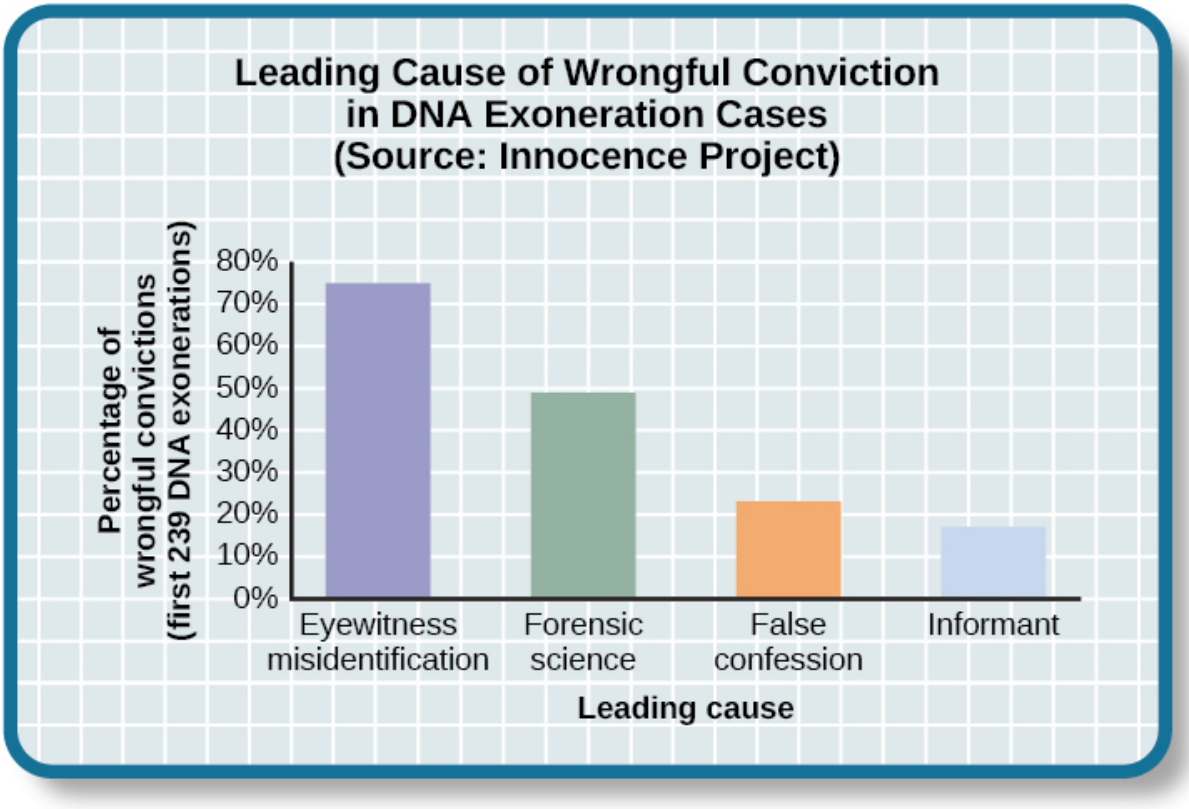
Most of the tips were dead ends, until a white van was spotted at the site of one of the shootings. The police chief went on national television with a

picture of the white van. After the news conference, several other eyewitnesses called to say that they too had seen a white van fleeing from the scene of the shooting. At the time, there were more than 70,000 white vans in the area. Police officers, as well as the general public, focused almost exclusively on white vans because they believed the eyewitnesses. Other tips were ignored. When the suspects were finally caught, they were driving a blue sedan.

As illustrated by this example, we are vulnerable to the power of suggestion, simply based on something we see on the news. Or we can claim to remember something that in fact is only a suggestion someone made. It is the suggestion that is the cause of the false memory.

Eyewitness Misidentification

Even though memory and the process of reconstruction can be fragile, police officers, prosecutors, and the courts often rely on eyewitness identification and testimony in the prosecution of criminals. However, faulty eyewitness identification and testimony can lead to wrongful convictions ([link]).



In studying cases where DNA evidence has exonerated people from crimes, the Innocence Project discovered that eyewitness misidentification is the leading cause of wrongful convictions (Benjamin N. Cardozo School of Law, Yeshiva University, 2009).

How does this happen? In 1984, Jennifer Thompson, then a 22-year-old college student in North Carolina, was brutally raped at knifepoint. As she was being raped, she tried to memorize every detail of her rapist's face and physical characteristics, vowing that if she survived, she would help get him convicted. After the police were contacted, a composite sketch was made of the suspect, and Jennifer was shown six photos. She chose two, one of which was of Ronald Cotton. After looking at the photos for 4–5 minutes, she said, "Yeah. This is the one," and then she added, "I think this is the guy." When questioned about this by the detective who asked, "You're sure? Positive?" She said that it was him. Then she asked the detective if she did OK, and he reinforced her choice by telling her she did great. These

kinds of unintended cues and suggestions by police officers can lead witnesses to identify the wrong suspect. The district attorney was concerned about her lack of certainty the first time, so she viewed a lineup of seven men. She said she was trying to decide between numbers 4 and 5, finally deciding that Cotton, number 5, “Looks most like him.” He was 22 years old.

By the time the trial began, Jennifer Thompson had absolutely no doubt that she was raped by Ronald Cotton. She testified at the court hearing, and her testimony was compelling enough that it helped convict him. How did she go from, “I think it’s the guy” and it “Looks most like him,” to such certainty? Gary Wells and Deah Quinlivan (2009) assert it’s suggestive police identification procedures, such as stacking lineups to make the defendant stand out, telling the witness which person to identify, and confirming witnesses choices by telling them “Good choice,” or “You picked the guy.”

After Cotton was convicted of the rape, he was sent to prison for life plus 50 years. After 4 years in prison, he was able to get a new trial. Jennifer Thompson once again testified against him. This time Ronald Cotton was given two life sentences. After serving 11 years in prison, DNA evidence finally demonstrated that Ronald Cotton did not commit the rape, was innocent, and had served over a decade in prison for a crime he did not commit.

Ronald Cotton’s story, unfortunately, is not unique. There are also people who were convicted and placed on death row, who were later exonerated. The Innocence Project is a non-profit group that works to exonerate falsely convicted people, including those convicted by eyewitness testimony. To learn more, you can visit http://www.innocenceproject.org.

Controversies over Repressed and Recovered Memories

Other researchers have described how whole events, not just words, can be falsely recalled, even when they did not happen. The idea that memories of traumatic events could be repressed has been a theme in the field of

psychology, beginning with Sigmund Freud, and the controversy surrounding the idea continues today.

Recall of false autobiographical memories is called **false memory syndrome**. This syndrome has received a lot of publicity, particularly as it relates to memories of events that do not have independent witnesses—often the only witnesses to the abuse are the perpetrator and the victim (e.g., sexual abuse).

On one side of the debate are those who have recovered memories of childhood abuse years after it occurred. These researchers argue that some children's experiences have been so traumatizing and distressing that they must lock those memories away in order to lead some semblance of a normal life. They believe that repressed memories can be locked away for decades and later recalled intact through hypnosis and guided imagery techniques (Devilly, 2007).

Research suggests that having no memory of childhood sexual abuse is quite common in adults. For instance, one large-scale study conducted by John Briere and Jon Conte (1993) revealed that 59% of 450 men and women who were receiving treatment for sexual abuse that had occurred before age 18 had forgotten their experiences. Ross Cheit (2007) suggested that repressing these memories created psychological distress in adulthood. The Recovered Memory Project was created so that victims of childhood sexual abuse can recall these memories and allow the healing process to begin (Cheit, 2007; Devilly, 2007).

On the other side, Loftus has challenged the idea that individuals can repress memories of traumatic events from childhood, including sexual abuse, and then recover those memories years later through therapeutic techniques such as hypnosis, guided visualization, and age regression.

Loftus is not saying that childhood sexual abuse doesn't happen, but she does question whether or not those memories are accurate, and she is skeptical of the questioning process used to access these memories, given that even the slightest suggestion from the therapist can lead to misinformation effects. For example, researchers Stephen Ceci and Maggie Brucks (1993, 1995) asked three-year-old children to use an anatomically

correct doll to show where their pediatricians had touched them during an exam. Fifty-five percent of the children pointed to the genital/anal area on the dolls, even when they had not received any form of genital exam.

Ever since Loftus published her first studies on the suggestibility of eyewitness testimony in the 1970s, social scientists, police officers, therapists, and legal practitioners have been aware of the flaws in interview practices. Consequently, steps have been taken to decrease suggestibility of witnesses. One way is to modify how witnesses are questioned. When interviewers use neutral and less leading language, children more accurately recall what happened and who was involved (Goodman, 2006; Pipe, 1996; Pipe, Lamb, Orbach, & Esplin, 2004). Another change is in how police lineups are conducted. It's recommended that a blind photo lineup be used. This way the person administering the lineup doesn't know which photo belongs to the suspect, minimizing the possibility of giving leading cues. Additionally, judges in some states now inform jurors about the possibility of misidentification. Judges can also suppress eyewitness testimony if they deem it unreliable.

Summary

All of us at times have felt dismayed, frustrated, and even embarrassed when our memories have failed us. Our memory is flexible and prone to many errors, which is why eyewitness testimony has been found to be largely unreliable. There are several reasons why forgetting occurs. In cases of brain trauma or disease, forgetting may be due to amnesia. Another reason we forget is due to encoding failure. We can't remember something if we never stored it in our memory in the first place. Schacter presents seven memory errors that also contribute to forgetting. Sometimes, information is actually stored in our memory, but we cannot access it due to interference. Proactive interference happens when old information hinders the recall of newly learned information. Retroactive interference happens when information learned more recently hinders the recall of older information.

Review Questions

Exercise:

Problem:

_____ is when our recollections of the past are done in a self-enhancing manner.

A. stereotypical bias
B. egocentric bias
C. hindsight bias
D. enhancement bias

Solution:

B

Exercise:

Problem: Tip-of-the-tongue phenomenon is also known as _____.

A. persistence
B. misattribution
C. transience
D. blocking

Solution:

D

Exercise:

Problem:

The formulation of new memories is sometimes called _____, and the process of bringing up old memories is called _____.

A. construction; reconstruction
B. reconstruction; construction

C. production; reproduction
D. reproduction; production

Solution:

A

Critical Thinking Questions

Exercise:

Problem: Compare and contrast the two types of interference.

Solution:

There are two types of interference: retroactive and proactive. Both are types of forgetting caused by a failure to retrieve information. With retroactive interference, new information hinders the ability to recall older information. With proactive interference, it’s the opposite: old information hinders the recall of newly learned information.

Exercise:

Problem: Compare and contrast the two types of amnesia.

Solution:

There are two types of amnesia: retrograde and anterograde. Both involve the loss of long-term memory that occurs as the result of disease, physical trauma, or psychological trauma. With anterograde amnesia, you cannot remember new information; however, you can remember information and events that happened prior to your injury. Retrograde amnesia is the exact opposite: you experience loss of memory for events that occurred before the trauma.

Glossary

absentmindedness
: lapses in memory that are caused by breaks in attention or our focus being somewhere else

amnesia
: loss of long-term memory that occurs as the result of disease, physical trauma, or psychological trauma

anterograde amnesia
: loss of memory for events that occur after the brain trauma

bias
: how feelings and view of the world distort memory of past events

blocking
: memory error in which you cannot access stored information

construction
: formulation of new memories

false memory syndrome
: recall of false autobiographical memories

forgetting
: loss of information from long-term memory

misattribution
: memory error in which you confuse the source of your information

misinformation effect paradigm
: after exposure to incorrect information, a person may misremember the original event

persistence
: failure of the memory system that involves the involuntary recall of unwanted memories, particularly unpleasant ones

proactive interference
: old information hinders the recall of newly learned information

reconstruction
: process of bringing up old memories that might be distorted by new information

retroactive interference
: information learned more recently hinders the recall of older information

retrograde amnesia
: loss of memory for events that occurred prior to brain trauma

suggestibility
: effects of misinformation from external sources that leads to the creation of false memories

transience
: memory error in which unused memories fade with the passage of time

8.4 Ways to Enhance Memory
By the end of this section, you will be able to:

- Recognize and apply memory-enhancing strategies
- Recognize and apply effective study techniques

Most of us suffer from memory failures of one kind or another, and most of us would like to improve our memories so that we don't forget where we put the car keys or, more importantly, the material we need to know for an exam. In this section, we'll look at some ways to help you remember better, and at some strategies for more effective studying.

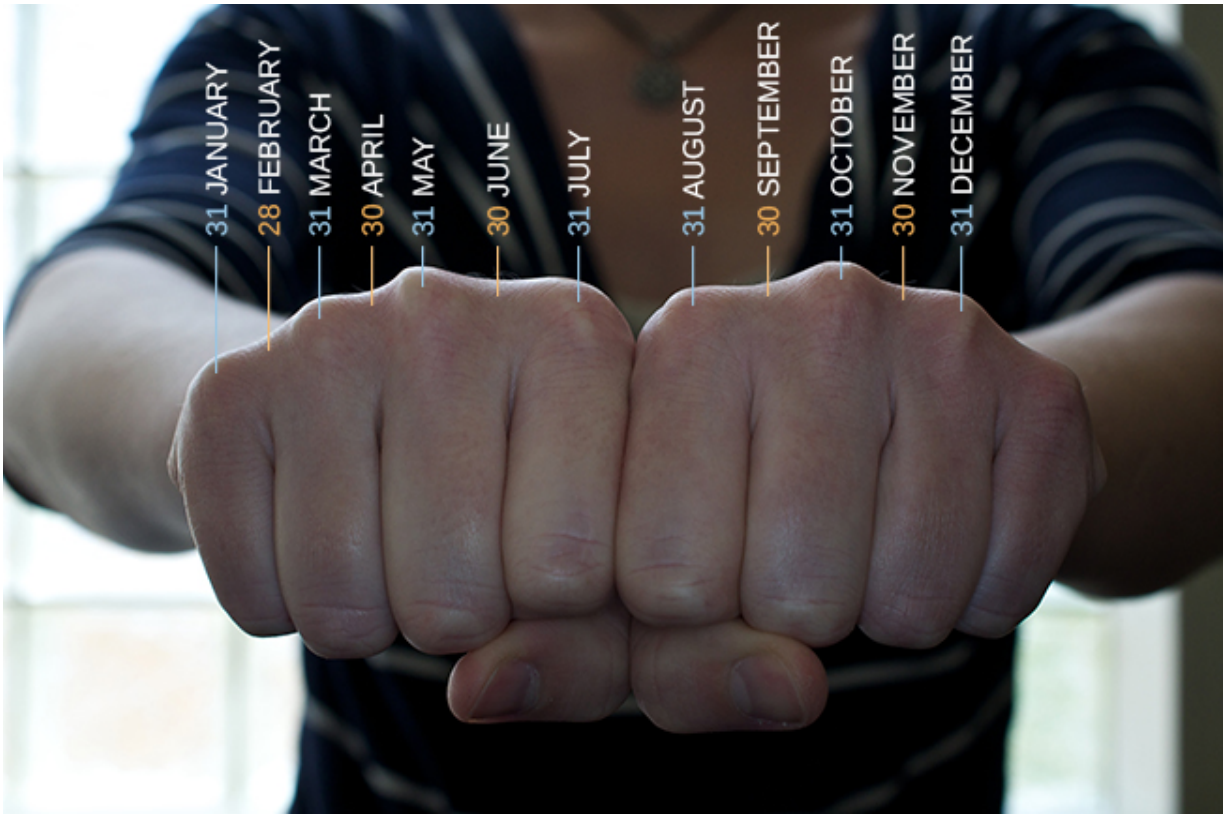
MEMORY-ENHANCING STRATEGIES

What are some everyday ways we can improve our memory, including recall? To help make sure information goes from short-term memory to long-term memory, you can use **memory-enhancing strategies**. One strategy is rehearsal, or the conscious repetition of information to be remembered (Craik & Watkins, 1973). Think about how you learned your multiplication tables as a child. You may recall that 6 x 6 = 36, 6 x 7 = 42, and 6 x 8 = 48. Memorizing these facts is rehearsal.

Another strategy is **chunking**: you organize information into manageable bits or chunks (Bodie, Powers, & Fitch-Hauser, 2006). Chunking is useful when trying to remember information like dates and phone numbers. Instead of trying to remember 5205550467, you remember the number as 520-555-0467. So, if you met an interesting person at a party and you wanted to remember his phone number, you would naturally chunk it, and you could repeat the number over and over, which is the rehearsal strategy.

You could also enhance memory by using **elaborative rehearsal**: a technique in which you think about the meaning of the new information and its relation to knowledge already stored in your memory (Tigner, 1999). For example, in this case, you could remember that 520 is an area code for Arizona and the person you met is from Arizona. This would help you better remember the 520 prefix. If the information is retained, it goes into long-term memory.

Mnemonic devices are memory aids that help us organize information for encoding ([link]). They are especially useful when we want to recall larger bits of information such as steps, stages, phases, and parts of a system (Bellezza, 1981). Brian needs to learn the order of the planets in the solar system, but he's having a hard time remembering the correct order. His friend Kelly suggests a mnemonic device that can help him remember. Kelly tells Brian to simply remember the name Mr. VEM J. SUN, and he can easily recall the correct order of the planets: **M**ercury, **V**enus, **E**arth, **M**ars, **J**upiter, **S**aturn, **U**ranus, and **N**eptune. You might use a mnemonic device to help you remember someone's name, a mathematical formula, or the seven levels of Bloom's taxonomy.



This is a knuckle mnemonic to help you remember the number of days in each month. Months with 31 days are represented by the protruding knuckles and shorter months fall in the spots between knuckles. (credit: modification of work by Cory Zanker)

Some other strategies that are used to improve memory include expressive writing and saying words aloud. Expressive writing helps boost your short-term memory, particularly if you write about a traumatic experience in your life. Masao Yogo and Shuji Fujihara (2008) had participants write for 20-minute intervals several times per month. The participants were instructed to write about a traumatic experience, their best possible future selves, or a trivial topic. The researchers found that this simple writing task increased short-term memory capacity after five weeks, but only for the participants who wrote about traumatic experiences. Psychologists can't explain why this writing task works, but it does.

What if you want to remember items you need to pick up at the store? Simply say them out loud to yourself. A series of studies (MacLeod, Gopie, Hourihan, Neary, & Ozubko, 2010) found that saying a word out loud improves your memory for the word because it increases the word's distinctiveness. Feel silly, saying random grocery items aloud? This technique works equally well if you just mouth the words. Using these techniques increased participants' memory for the words by more than 10%. These techniques can also be used to help you study.

HOW TO STUDY EFFECTIVELY

Based on the information presented in this chapter, here are some strategies and suggestions to help you hone your study techniques. The key with any of these strategies is to figure out what works best for you.

- **Use elaborative rehearsal**: In a famous article, Craik and Lockhart (1972) discussed their belief that information we process more deeply goes into long-term memory. Their theory is called **levels of processing**. If we want to remember a piece of information, we should think about it more deeply and link it to other information and memories to make it more meaningful. For example, if we are trying to remember that the hippocampus is involved with memory processing, we might envision a hippopotamus with excellent memory and then we could better remember the hippocampus.

- **Apply the self-reference effect**: As you go through the process of elaborative rehearsal, it would be even more beneficial to make the material you are trying to memorize personally meaningful to you. In other words, make use of the self-reference effect. Write notes in your own words. Write definitions from the text, and then rewrite them in your own words. Relate the material to something you have already learned for another class, or think how you can apply the concepts to your own life. When you do this, you are building a web of retrieval cues that will help you access the material when you want to remember it.
- **Don't forget the forgetting curve**: As you know, the information you learn drops off rapidly with time. Even if you think you know the material, study it again right before test time to increase the likelihood the information will remain in your memory. Overlearning can help prevent storage decay.
- **Rehearse, rehearse, rehearse**: Review the material over time, in spaced and organized study sessions. Organize and study your notes, and take practice quizzes/exams. Link the new information to other information you already know well.
- **Be aware of interference**: To reduce the likelihood of interference, study during a quiet time without interruptions or distractions (like television or music).
- **Keep moving**: Of course you already know that exercise is good for your body, but did you also know it's also good for your mind? Research suggests that regular aerobic exercise (anything that gets your heart rate elevated) is beneficial for memory (van Praag, 2008). Aerobic exercise promotes neurogenesis: the growth of new brain cells in the hippocampus, an area of the brain known to play a role in memory and learning.
- **Get enough sleep**: While you are sleeping, your brain is still at work. During sleep the brain organizes and consolidates information to be stored in long-term memory (Abel & Bäuml, 2013).
- **Make use of mnemonic devices**: As you learned earlier in this chapter, mnemonic devices often help us to remember and recall information. There are different types of mnemonic devices, such as the acronym. An acronym is a word formed by the first letter of each of the words you want to remember. For example, even if you live near

one, you might have difficulty recalling the names of all five Great Lakes. What if I told you to think of the word Homes? HOMES is an acronym that represents Huron, Ontario, Michigan, Erie, and Superior: the five Great Lakes. Another type of mnemonic device is an acrostic: you make a phrase of all the first letters of the words. For example, if you are taking a math test and you are having difficulty remembering *the order of operations*, recalling the following sentence will help you: "Please Excuse My Dear Aunt Sally," because the order of mathematical operations is Parentheses, Exponents, Multiplication, Division, Addition, Subtraction. There also are jingles, which are rhyming tunes that contain key words related to the concept, such as *i before e, except after c*.

Summary

There are many ways to combat the inevitable failures of our memory system. Some common strategies that can be used in everyday situations include mnemonic devices, rehearsal, self-referencing, and adequate sleep. These same strategies also can help you to study more effectively.

Review Questions

Exercise:

Problem:

When you are learning how to play the piano, the statement "Every good boy does fine" can help you remember the notes E, G, B, D, and F for the lines of the treble clef. This is an example of a (an) _____.

A. jingle
B. acronym
C. acrostic
D. acoustic

Solution:

C

Exercise:

Problem:

According to a study by Yogo and Fujihara (2008), if you want to improve your short-term memory, you should spend time writing about _____.

A. your best possible future self
B. a traumatic life experience
C. a trivial topic
D. your grocery list

Solution:

B

Exercise:

Problem: The self-referencing effect refers to _____.

A. making the material you are trying to memorize personally meaningful to you
B. making a phrase of all the first letters of the words you are trying to memorize
C. making a word formed by the first letter of each of the words you are trying to memorize
D. saying words you want to remember out loud to yourself

Solution:

A

Exercise:

Problem:

Memory aids that help organize information for encoding are _____.

A. mnemonic devices
B. memory-enhancing strategies
C. elaborative rehearsal
D. effortful processing

Solution:

A

Critical Thinking Questions

Exercise:

Problem:

What is the self-reference effect, and how can it help you study more effectively?

Solution:

The self-reference effect is the tendency an individual to have better memory for information that relates to oneself than information that is not personally relevant. You can use the self-reference effect to relate the material to something you have already learned for another class, or think how you can apply the concepts to your life. When you do this, you are building a web of retrieval cues that will help you access the material when you want to remember it.

Exercise:

Problem:

You and your roommate spent all of last night studying for your psychology test. You think you know the material; however, you suggest that you study again the next morning an hour prior to the test. Your roommate asks you to explain why you think this is a good idea. What do you tell her?

Solution:

You remind her about Ebbinghaus's forgetting curve: the information you learn drops off rapidly with time. Even if you think you know the material, you should study it again right before test time to increase the likelihood the information will remain in your memory. Overlearning can help prevent storage decay.

Glossary

chunking
: organizing information into manageable bits or chunks

elaborative rehearsal
: thinking about the meaning of the new information and its relation to knowledge already stored in your memory

levels of processing
: information that is thought of more deeply becomes more meaningful and thus better committed to memory

memory-enhancing strategy
: technique to help make sure information goes from short-term memory to long-term memory

mnemonic device
: memory aids that help organize information for encoding